Industrial Land Price and its Impact on Urban Growth: a China study

Abstract:

China is experiencing rapid progress in industrialization, with its own rationale towards industrial land development based on a deliberate change from an extensive to intensive form of urban land use. One result has been concerted attempts by local government to attract foreign investment by a low industrial land price strategy, which has resulted in a disproportionally large amount of industrial land within the total urban land use structure at the expense of the urban sprawl of many cities. This paper first examines "Comparable Benchmark Price as Residential land use" (CBPR) as the theoretical basis of the low industrial land price phenomenon. Empirical findings are presented from a case study based on data from Jinyun County, China. These data are analyzed to reveal the rationale of industrial land price from 2000 to 2010 concerning the CBPR model. We then explore the causes of low industrial land prices in the form of a "Centipede Game Model", involving two neighborhood regions as "major players" to make a set of moves (or strategies). When one of the players unilaterally reduces the land price to attract investment with the aim to maximize profits arising from the revenues generated from foreign investment and land premiums, a two-player price war begins in the form of a dynamic game, the effect of which is to produce a downward spiral of prices. In this context, the paradox of maximizing profits for each of the two players are not accomplished due to the inter-regional competition of attracted investment leading to a lose-lose situation for both sides' in competing for land premium revenues. A short-term solution to the problem is offered involving the establishment of inter-regional cooperative partnerships. For the longer

term, however, a comprehensive reform of the local financial system, more adroit regional planning and an improved means of evaluating government performance is needed to ensure the government's role in securing pubic goods is not abandoned in favor of one solely concerned with revenue generation.

Keywords: Land use, industrial land price, urban growth, Centipede Game Model, China.

1 Introduction

Since the 1990s, China has gradually established and improved its socialist market economy, boosting its progress in industrialization and urbanization. As a result, a large number of urban construction and industrial parks have taken the place of what was formerly cultivated land, increasing China's grain supply security risks and reliance on imported food products. At the same time, international food reserves have fallen to their lowest levels in history, raising questions over the ability of the international grain market to meet future Chinese food deficits.

This situation was recognized as long ago as 1995 in the World Watch Institute's report *Who will feed China?* (Brown, 1995), alerting the Chinese nation to the importance of protecting their cultivated land (Wu *et al*., 2002). Subsequently, in 1997, the CPC Central Committee and State Council issued its *To further strengthening land management to protect arable land effectively*, authorizing the establishment of a comprehensive inventory of all types of construction land in existence since 1991. This was followed in 1998 by modifications to *The Land Administration Law of People's Republic of China*, which provided land use control and strictly limited the conversion of agricultural land to non-agricultural land. These policies

should have deterred the replacement of agricultural land by construction land. However, according to the 2003 national industrial park inventory, the number of industrial parks was 5658 with a planning area of 36,000 km^2, which exceeds the total China urban construction land area at that time (Chen, 2004). It is clear, therefore, that the problems of industrial-agricultural land imbalance as well as the extensive industrial land use are far from resolved as yet (Hong, 2007).

Land prices are closely related to urban growth, particularly in China, which acts as a 'world factory' and requires much industrial land (Zhang, 2006). Industrial land prices are therefore considered the decisive driving force behind urban growth. According to the classic mono-centric theory of urban economics, employment centers are usually situated in the city center (CBD). By using different types of land bid-rent curve analyses, the urban spatial structure model (O'Sullivan, 2000) was established (as shown in Fig. 1). Clearly, different forms of bid-rent curves (for commercial land, residential land, industrial land, etc.) affect urban spatial structure and city size. Assuming the bid-rent curves for commercial land and residential land remain unchanged, it is obvious that changes in the slope of the industrial land bid-rent curve will have a significant impact. When the prices of industrial land tracts are relatively high, the slope of the bid-rent curve is greater and the spatial distribution of industrial land is located between commercial and residential sites. At the same time, the land structure within the city boundary is determined by the slope of bid-rent curve of residential land (Fig. 1a). On the other hand, when industrial land prices are relatively low, the bid-rent curve slope is flat and the spatial distribution of industrial land is located outside of residential sites. In this case, the land structure within the city boundary is determined by the slope of the bid-rent curve

of industrial land (Fig. 1b). That is to say, theoretically, low industrial land prices (Fig.1b) would be the cause of the phenomenon of urban sprawl in China.

<Insert Figure 1 here>

Therefore, two basic hypotheses are proposed in this paper: (1) the policy of low industrial land prices lead to too great a proportion of industrial land within the overall urban land use structure, which therefore indicates that the ever-increasing amount of industrial land is an important driving force behind China's urban growth; and (2) the cause of low industrial land prices is the intensity of inter-regional competition in attempting to attract foreign investment, resulting in the urban sprawl of many cities, as shown in Fig. 1b.

2 Industrial land use policy in China

2.1 Review of industrial land allocation policies

Since the founding of the new PRC in 1949, China's industrial land allocation policies have gone through many stages, during which the role of market has varied.

Stage I: 1949-1954, state ownership of industrial land with low fees or rent

In the early period, the co-existence of state-owned and private land prevailed. Private land could be traded, rented, etc. Later, the government transferred most of urban land to stated-owned land, typically by administrative take-over, confiscation, redemption and legal announcement. The state ownership of land was therefore gradually established. During this period, individuals and institutions had to pay rent or fees, controlled and regulated by the government, in order to use the land. Government action therefore gradually replaced the

market in allocating industrial land at this stage.

Stage II: 1955-1978, government assignment of industrial land use

In 1954, the rent and fees for land use were cancelled at the behest of the Financial Secretary and Department of Interior. Payments from individuals and institutions were no longer needed, lands for construction were allocated according to the overall land resource plan, and no land beyond these plans could be used. As a result, the land no longer constituted merchandise and the land market disappeared.

Stage III: 1979-1991, co-existence of government assigned and paid use of industrial land

Since 1979, with the reform of rural land use, farmers possessed title to long-term use rights though the land remained collectively owned. This greatly stimulated China's agricultural productivity. At the same time, with the continuous development of township enterprises, the economy started to boom, which prompted urban industrial land use management into a reform agenda in the 1980s. In 1987, for the first time, land in the Shenzhen Special Economic Zone was transferred through grant by negotiation and auction (Zhu, 1994). In the same year, with the State Council's proposal for the transferability of land use rights in the free market, pilot reform tests were further conducted at Fuzhou, Haikou, Guangzhou, Xiamen, Shanghai and Tianjin.

Stage IV: 1992-now, exploration development of industrial land

In 1992, the establishment of a socialist market economy status by the central government

was formally determined. Urban construction in China, particularly that in industrial parks, mushroomed in various places. In order to curb the momentum of cultivated/agricultural land occupied by rapid urbanization and industrialization the *Land Management Law* was amended in 1998 in order to establish improved land use control.

2.2 Policy for industrial parks

In 2001, the industrial land use right transfer was introduced to terminate the non-competitive *Agreement-based assignment of the right to state-owned land use* in favor of the competitive *tender, bid and auction approach to state-owned land use* (the so-called "zhao pai gua"). Since 2006, the Ministry of Land and Resources has issued its *Minimum price standards for the transfer of land for industrial use* and *Industrial land control targets*. This led to China's "world factory" role, with the dramatically expanding development of its large-sized industrial parks. In Zhejiang Province, for example, the number of estimated planning development zones reached 754 in 2005 while the actual number of development zones approved was only 80.

The planning areas of industrial parks in Zhejiang Province's 11 prefecture-level cities are summarized in Table 1. As shown, the total area of the parks is around 1067 hectares, in contrast with a total central urban built-up area of only 1262 hectares. Likewise, for the individual urban centers of Ningbo, Jiaxing, Huzhou, Jinhua and Taizhou City, the total area of industrial parks exceeds that of total urban built-up area.

<Insert Table 1 here>

3 Industrial land use and urban growth management: key literature

The two major issues regarding industry development and the impact on industrial land concern employment and pollution. This is reflected in the two major topics - “Location” and “Zoning” - found largely in the early literature (Weber and Friedrich, 1929; Alonso, 1964; Miller and de Roo, 1997). There, an obvious difference in research focus is apparent between developing and developed countries. With developed countries, the research is not focused on increased industrial land, but on sustainable development. As Ziegler (2009) points out, a metropolitan sustainable development governing framework for growth management in the twenty-first century is essential for a sustainable future.

A particularly important recent Western study by Liu et al (2007) couples human and natural systems to reveal new and complex patterns and processes. Their synthesis of six case studies from around the world shows that such couplings vary across space, time, and organizational units. The nonlinear dynamics involved, with thresholds, reciprocal feedback loops, time lags, resilience, heterogeneity and surprises are also demonstrated, with couplings having legacy effects on present conditions and future possibilities. In Ziegler’s (2009) case, this includes both the provision of higher-density urban centers and transit-oriented development centers, and a change in public attitude away from “not in my back yard” thinking. Using 1998 to 2003 panel data from 406 Florida cities, Lubell *et al* (2009) conducted an empirical analysis to identify important interaction effects between the structure of city executive branch institutions and interest group variables. Institutional structure helps determine which interest groups’ preferences are reflected in local land-use changes and development patterns. The resulting patterns suggest a “sustainability paradox”, in which richer,

environmental interests pursue the preservation of environmental amenities while at the same time accelerating the number of residential units built in a community.

With developing countries, the research focus emphasizes urban growth management in the process of urbanization in addition to industrialization. Some scholars apply the concept of 'urban growth boundaries (UGB)', already in use in the early period of developed countries, to urban growth research in developing countries. UGB is a regulatory measure used by local government for delineating the limits of urban growth over a period of time. Land within the UGB allows urban development, while the land outside remains primarily non-urban. Recently, UGB management rules have been extensively applied in the urban land-use management discipline in developing countries. For example, Bhattaa (2009) introduced the concept model 'ideal urban radial proximity' (IURP), involving the increasing popularity, urban vegetation, water bodies and other important non-urban areas within the inner city space to designate a spatial UGB using geo-informatics in a digital environment. This conceptual model has been applied in the Kolkata urban agglomeration in India. In China, Feng et al. (2010) put forward the concept of Urban Construction Boundary (UCB). Three indicators on boundary control were proposed, including the effectiveness of boundary containment, land inventory sufficiency and illegal adjacent development to the UCB. It is found that the effectiveness of urban construction boundary containment is not good and it is not binding well. There is still much room for improvement in the future. Bae and Sellers (2007), on the other hand, explore the politics of urban growth in a transitional society in Korea. Here, a multilevel analysis approach is established to show that the transformations in Korea as a late industrializer, late democratizer and late adopter of urban policy have helped to consolidate more restricted

policies on urban growth than in the USA and much of Europe. The research findings further highlight the dynamics involved at global, national and local levels to explain the similarities and differences in the growth politics of a transitional society such as Korea with those of older industrialized democracies. Similarly, Zhao *et al* (2009) investigated the decentralized-concentration strategy, one of the most important metropolitan growth management initiatives in Beijing since the 1990s, to better understand the effectiveness of growth management in a transformational context. The results suggest that the aims of municipal growth management to concentrate developments in the urban fringe have been partly achieved through actual local development; while some unexpected and illegal local developments outside the planned areas have been counterproductive. The performance of present growth management is also being challenged by new trends in political decentralization and changed local fiscal responsibilities.

With the rapid process of urbanization and industrialization, there have been many studies of industrial land use in China, with the intensive use of industrial land becoming a major focus. For example, Wu (2007) considers the critical determinants of extensive land use to be the very low industrial land use prices occurring because of intense competition among regions to attract foreign investment. Lu *et al* (2006) argue that industrial land is the main driving force behind urban land expansion and, as a result, controlling and guiding increased industrial land use is the key to achieving its sustainability. Along these lines, Jia *et al* (2010) holds that it is necessary for China to adopt industrial land planning, standards, preliminary review as well as monitoring overall industrial land intensive use. In addition, an analysis of industrial land use in Ningbo indicates the local economic development level to be an important factor affecting the

intensive use of industrial land (Li *et al*., 2008). Gu *et al* (2009) believe that selecting different industries for different areas will help promote overall intensive land use planning.

In comparison with the literature relating to developing countries, studies of industrial land use in most of developed countries focus on the risks in industrial land redevelopment, such as those involved in the development and utilization of brownfield land (Sigman, 2010; Adams *et al*, 2010). Zhu (2000) points out that industrial land use policy often changes due to industrial economic development needs followed by rapid global economic development. Meanwhile, Wong and Tang (2005) indicate that a great deal of vacant land is found in the Economic and Technological Development Zone of China due to 'development zone fever', which has resulted in both the waste of valuable land resources' and inefficient land use.

In short, most studies have been of industrial land use in addition to urban growth management from the perspective of planning, while very little systematic research has been conducted in terms of the combination of market and planning strategies. This paper, therefore, aims to explicate the driving forces as well as causes behind the burgeoning industrial land in China from the perspective of land transfer prices, as a contribution to the regulation of urban growth in developing countries in general. The data is collected from the local land transfer database in a county region of Zhejiang Province.

4 The Case of Jinyun County

Jinyan is a Chinese county - an administrative unit of very important historical and realistic significance in China as reflected in the mantra *Junxian zhi, Tianxia an* (If the counties are well managed, the whole country will be peaceful and prosperous). In China's administrative

structure, counties are ranked below prefecture-level cities, with each prefecture-level city having jurisdiction over a number of counties. A county with a larger population or economic scale is termed a 'county-level city'. For example, Shenzhen is ranked as "a prefecture-level city", while Yiwu (renowned for its small commodity trading) is classified as "county-level city". There are a total of 285 prefecture-level cities, 368 county-level cities and 1570 counties (MCA, 2012). The extreme importance of the role that the county unit plays in the national power structure and development strategy has provided it with independent rights in administration, judicial, financial and other sectors, and the exercise of land use right transfers (Chen *et al*., 2006).

In this paper, industrial land use prices at the County level are analyzed to understand the relationship between the selling prices and proportion of urban land involved, and to interpret the effects of increased amounts of industrial land on urban growth. A dynamic game theory approach is then used to further assess the influence of low industrial land prices on regional industry development. Fig. 2 illustrates what is involved.

<Insert Figure 2 here>

4.1 Case area

The district analyzed in this study, Jinyun County in Zhejiang Province, is a typical County unit in China. It is located in Lishui City, covering an area of 1495 km^2 and with a population of 453,404 in 2010 (Fig. 3). At distance of 300*km* from Shanghai, Jinyun County is a 'relatively developing region' in the south of Zhejiang Province. The year 2002 marked the opening of the highway from Jinyun County to Hangzhou, the capital of Zhejiang Province – greatly

improving access to the County. According to the sixth Census data in China, the population of Jinyun County is 358,900. It is ranked 18th of the 36 administrative counties in Zhejiang Province, which makes it very representative of China's coastal regions. In 2010, the overall GDP of Jinyun was RMB$10.78 billion, with the proportion of three major industrial sectors (agriculture, industry, and services) being "6:60:34" respectively.

<Insert Figure 3 here>

4.2 Comparative analysis of industrial land prices and residential land prices

As early as the Ninth Five-Year Plan period (2001-2005), Wen Jiabao, the Premier of the Chinese State Council, announced its intention to move the country's economic growth from an extensive to intensive mode although, as yet, the extensive mode of growth still dominates (Wen, 2005). In terms of land use, the supply of industrial land use is particularly acute (Hong, 2007). As the most critical determinant of industrial land use availability are very low industrial land transfer prices, the Ministry of Land and Resources issued its *Minimum price standards for the transfer of land for industrial use*, followed by various local implementation rules in different provinces. As is shown by local survey data, however, the very low industrial land prices have prevented the desired fundamental change of urban growth from extensive use to intensive use. During the period 2000-2010, 364 tracts of industrial land with a mean value of 123 yuan/m^2 (106 yuan/m^2, 634 yuan/m^2 and 25 yuan/m^2 for the median, highest and lowest prices respectively), were transferred by bid and agreement (Fig. 4).

<Insert Figure 4 here>

However, industrial land prices were relatively lower than the sale prices of residential land during the same period, with the average bid price of residential land during 2000 to 2010 being 3816 yuan/m^2 - increasing after 2007 to 4865 yuan/m^2.

As the policies for industrial land use and residential land use are different, equivalent values need to be established in line with the relevant parameters of *Industrial land control targets*. On one hand, the regulations require that the proportion of the land area of administrative office and living facilities cannot exceed 7% of the overall amount of project land In fact, the administrative office and living facilities can be used as residential houses for workers, and so the land area involved is equivalent to residential land. On the other hand, the maximum term of residential land use is 70 years and that of industrial land use is 50 years. According to current rates, the interest rate of bank loans with a maturity of 5 years is 5.94%, while the conversion ratio of industrial land to residential land is 0.9620. This is calculated by the Capitalized approach on condition that the term of 70 years is equivalent to 98.3% of the indefinite and the term of 50 years is equivalent to 94.6% of the indefinite. To sum up, the comparison of benchmark relations on characteristics and conversion price between industrial and residential land is shown in Table 2.

<Insert Table 2 here>

In line with Table 2, a theoretical model named the “Comparable benchmark price as residential land use” (CBPR) was therefore established for use as a method of converting industrial land prices to residential land prices in Jinyun from 2000 to 2010, where

$$CBPR = IP / RALO / CRIR$$

$$= 123/7\%/0.9620$$

$$=1826 \text{ (Yuan/m}^2\text{)}$$

where IP denotes the “Industrial land transfer price”, RALO the “the ratio of land area of administrative office and living facilities to the overall land area” and CRIR the “conversion ratio of industrial land to residential land”.

In this study, the CBPR is a type of shadow price model. In the model, the total industrial land transfer fee is completely projected onto land for the administrative office and living facilities (7% of overall industrial project land) in order to gain the CBPR. In fact, the CBPR is comparable with the residential land transfer price, so that the land area of administrative offices and living facilities can be used as residential houses for the workers, which is equivalent to residential land area. The comparative price of residential housing in Jinyun County is 1826 yuan/m^2, which is only 48% of the average price of open lease-out residential land at 3816 yuan/m^2 (Table 2). As the function of land area for administrative office and living facilities is similar to that for residential houses in suburban areas, the enterprises can obtain the land compensation fee providing 93% of the land is idle. Briefly, if 7% of the industrial land can be used as residential project development, it is inevitable for enterprises to acquire industrial land (not for sale), by which to develop the disguised form of residential project development (for sale). Similarly, the comparable residential price in Jinyun after 2007 was 177/7%/0.962=2629, which is 54% of the average price of residential land at 4865 yuan / m^2 (see Table 3).

<Insert Table 3 here>

According to the rule of substitutability between land and capital, rational enterprises

choose a combination of factor proportions including largest land area and minimal funds when industrial land price is very low, and which will therefore lead to extensive land use. In this way, low industrial land prices produce a potential price advantage induced by the search for change of land use type, and which eventually leads to the loss of state assets. With the establishment of a low price policy of industrial land from 2000 to 2010, the industrial and warehousing land accounts for a significantly higher proportion of new built-up land of 864 hectares in Jinyun. The new urban built-up land can be divided into four types, comprising public administration and infrastructure services land, industrial and warehousing land, residential land and commercial land. According to the 2000-2010 statistics, the amount of new urban land for the four types is 257.38, 480.81, 112.65 and 13.07 hectares respectively, with industrial and warehousing land space accounting for 55.65% of the total (Fig. 5).

<Insert Figure 5 here>

Corresponding with Jinyun's 2001-2020 comprehensive urban planning, industrial and warehousing land is 49.9 hectares, accounting for 13.1% of the total urban land use area. According to the original comprehensive urban planning of Jinyun, new industrial and warehousing land area was intended to be 93.0 hectares, or 16.9% of the total urban land use area of 142.9 hectare. In practice, however, new industrial and warehousing land area increased to 480.81 hectares, accounting for 55.65% of total new construction land. Obviously, the original comprehensive urban planning was not well implemented, resulting in the proportion of industrial land area being too large and therefore preventing the intended change from extensive land use to intensive land use.

As shown above, the proportion of industrial and warehousing land is too high which is resulted by the relatively low industrial price (Fig. 5). The ever-increasing industrial land has therefore become the key driving force behind China's rapid urban growth. This phenomenon is echoed with the Hypothesis (1) in this study. The overwhelming proportion of industrial land in urban areas, that has occurred as a result of the low industrial land price policy, has made industrial land development the major driving force of urban growth in China.

5 Centipede game model: causes of low industrial land prices

In China, there is often a lack of capital for local government to promote economic growth (e.g., to develop industrial parks) (Xu *et al*., 2009). If a low industrial land price policy is conducive to attracting investment, then the government's behavior and policy is clearly rational. As is well known, urban development (and the development of industrial parks in particular) can produce beneficial effects on the accumulation of production factors to realize the economies of scale.

In the short term, the development of industrial land meets both government GDP targets and the employment needs of the population; while in the long-term, industrial development can provide a guarantee for future local fiscal revenue. Lishui City, as one of the relatively backward areas in Zhejiang Province, has been seeking the synchronization of modernization with the overall development of the province since entering the new millennium. Jinyun's strategy of *Using industry to make county powerful* echoes the spirit of regional planning in Lishui City.

Although the low industrial land premium policy is aimed at attracting investment in China,

it actually results in a policy game played between regions. The results from the game theory analysis between regions not only affect the land use mode (whether it is intensive or extensive) but their attraction of foreign investment (see Table 4). When the total investment is fixed and other factors affecting investment remain the same, the land premium often becomes the determining factor in attracting investment. Suppose we need to decide whether to invest in regions *L* or *J* when they choose to adopt the normal land premium policy (J_1 and L_1 in Table 4), not only is land use intensified but the investment attractions from both sides remain unaffected.With a fixed total investment, investment attraction becomes a zero-sum game. Therefore, if region *L* adopts a low-premium policy, it will attract more investment with region *J* attracting less investment. If, to correct the situation, region *J* also adopts a low-premium policy, both the investment attractions are affected with extensive land use mode (see Table 4).

<Insert Table 4 here>

The GDP per capita in Jinyun has risen from $700 in 2001 to $3500 in 2010. In correspondence with the Hollis Chenery's patterns of development approach (Chenery, 1968), urban development at the expense of rural development can lead to a substantial loss of equality between internal regions of a country. Similar to experiences in North European Countries, Jinyun is currently undergoing a transition period from early to midterm industrialization, which makes it consistent in terms of overall growth in industrial land and economic development. The situation in Jinyun is also closely related to China's participation in the international division of labor since it entered the WTO in 2000. The significant influence of

Made in China in the global context has also spawned a large number of industrial land areas. Similarly, a large-scale increase in industrial land is quite common in developed coastal areas and other parts of China. For example, land expropriation in the Heilongjiang Province in 2010 resulted in 48% of land earmarked for use in future industrial development.

There is a precedent for low industrial land prices in the initial stages of industrial development. For example, industrial park development policies were implemented in Hong Kong in 1977. Land prices in the 1980s within the industrial park were lowered to HK $ 1000/m^2 while the land price in the open public market at the same period was around HK $ 4000-8000/m^2 (Lao and Cai, 1992). This low industrial land price policy encouraged many manufacturers that were originally located in urban industrial buildings to relocate to more rural areas, thereby reducing the industries' negative impact on the urban environment. In this way, some well-known high-tech manufacturers were also attracted to Hong Kong. In contrast, although most of the regions in mainland China implemented a low industrial land price policy with the intention of attracting investment, it did not yield good results. The reasons for this have not been established although dynamic game theory offers some apparent insights.

One approach is to invoke *Centipede Game Theory*. This exists in many different versions (Aumann, 1998; Sperry-Taylor, 2011). The earliest, put forward by Rosenthal (1981), was tailored for chain store pricing decisions under complete information. This is an extensive game form in which two players take turns choosing to take either a slightly larger share of a slowly increasing pot, or to pass the pot to the other player. This was later represented by a "Centipede Model" by Binmore (1987) involving two relevant parties in which players demonstrate a dynamic chess game.

In terms of the industrial land price issue, we assume that, if the loss incurred in reducing industrial land prices by local government is less than the investment income obtained, a price-cutting spiral occurs between regions. Now, assume the two regions each obtain '100' original revenue from land sales and the revenue generated after the attracting investment is also '100' each. Suppose the total amount of investment remains unchanged while the amount of attracted investment can be divided into several parts. For example, if there is 1% reduction in land price in the '*L*' region, there might be a concomitant 2% increase in the normal premium returning to the revenues of the '*J*' region. This process is demonstrated and depicted in Fig. 6.

<Insert Figure 6 here>

This depicts the decision making process between the two sides (the *L* side is above the centerline, while the J side is below the centerline) and can be explained in term of a series of steps:

Step 1: Say the decision of '*L*' is intended to be a "no trick" strategy. This means the two parties both take normal industrial land prices and are awarded with their individual revenues of attracted investment. The total amount of revenue is therefore 200 (100 land revenue and 100 investment revenue).

Step 2: When the *J* side is informed of the decision made by the *L* side, the *J* side proceeds to Step 2. In this case, the land price falls by 1%, resulting in an 2% increase in investment earnings so that the land price becomes 99, investment revenue 102, and total revenue 201 (which is better than the 200 in Step 1). Following the assumption made earlier, the total amount of investment remains unchanged. The increased foreign investment revenues are from

the '*L*' side, which results in lower total income of 198 on the '*L*' side.

Step 3: The '*L*' side is also individually rational, so it decides to reduce its land prices by 2%, 1% more than the '*J*' side, to 98. The investment earnings from '*L*' then become '102' and the total income '200' (which is better than *L*'s total income of 198 in Step 2). At the same time, the total income of the '*J*' side reduces to '197'.

Step 4: In response,the '*J*' side changes its strategy again by making a 3% reduction in land prices, which is 1% greater than the '*L*' side. Investment earnings from '*J*' are now '102' and the total income is '199' (which is better than *J*'s total income of 197 in Step 3). At the same time, the total income of the '*L*' side becomes '196'.

……

Step 101: By this time, the '*L*' side lowers its land price to '0', which is 1% more than the '*J*' side. The investment earnings from '*L*' now become '102' with total income '102' (which is better than *L*'s total income of 101 in Step 100). At the same time, the investment earnings and total income of '*J*' are '98' and '99' respectively.

Obviously, if there is no minimum limit to industrial land prices, the game eventually stays at Step 101 since this is the point of the zero limit of the land price. With minimum price policy restrictions, for example, a minimum transfer land price of 50% of the market price, the dynamic game theory process will stay at Step 51. In fact, as Fig. 6 implies, there are no fundamental changes in investment attractions in the regions '*J*' and '*L*'. In this way, therefore, a loss of land prices in both of the regions has occurred.

From a practical point of view, it should be noted that the Chinese government has identified the harm done by low industrial land prices, and the State Council issued an industrial

land market-oriented policy in 2006 mandating the land bidding/auctions mode. However, the policy has not fundamentally solved the low industrial land price problem to date. The industrial land prices from 2000 to 2010 in Jinyun have not reflected market competition (Fig. 7) as they continued to be 100-150 yuan/m^2 from 2000 to 2007. Since 2007, land prices have actually accelerated as a result of the minimum industrial land price policy change.

<Insert Figure 7 here>

The industrial land prices during the 2007-2010 period further suggest that the influence of market competition has dropped despite the increase in the minimum land price, with land prices generally ranging between 160-180 yuan/m^2 (Fig. 8). In addition, it has been demonstrated both theoretically and empirically that share price changes driven by market factors tend to follow a normal probability distribution (Praetz, 1972). However, as Fig. 8 shows, the distributional shape of Jinyun's industrial land price changes is far from that of a normal probability distribution, suggesting that changes in industrial land transfer are not driven by free market factors but by local government actions in endeavoring to attract investment.

<Insert Figure 8 here>

Theoretically speaking, the price of land-use depends on land-use type, location, land-use density, and neighborhood externalities (Ding, 2003). Location plays a key role in determining the land price providing the land use types are same (e.g., all are industrial land). However, the above-mentioned phenomenon is not reflected in Fig. 8, where industrial land prices appear to be mostly similar irrespective of their location. Instead, the slope of the industrial land bidding

curve in Fig.1b other than Fig.1a, indicates that the urban boundary is determined by the expansion of industrial land. The *Land bidding/auctions mode* of industrial land transfer does not promote the formation of a land market and no fundamental approach seems to be available to solve the problems of low industrial land prices. The industrial land prices appear to be concentrated within the range of 160-180 yuan/m^2, which reflects the phenomenon of the low industrial land price policy mandated by local government (Fig. 8). As Wu (2007) suggests, this may be due to the intensity of inter-regional competition in attempting to attract foreign investment.

The direct competitor of Jinyun is the Liandou district – the only political city center nearby – with Jinyun County and Liandou both being on the railway and highway to Shanghai and Hangzhou. After the tax system reforms in 1994, the central government's fiscal revenue has kept increasing year by year, although the local government's fiscal revenue has reduced in recent years (Jia and Yan, 2005). In order to resolve the shortage of funds resulting from the process of industrialization, the Liandou government has adopted a strategy of attracting foreign investment through low industrial land prices and hence helping to maintain similarly low prices of its regional neighbors.

The mean of industrial land price in Lishui is 159 yuan/m2, while that of Jinyun County is 177 yuan/m^2, which is similar to the Liandou District, higher than other counties and lower than the Qingtian County (229 yuan/m^2). This is caused largely by the behavior of the various parties involved and forces all to maintain low limit transfer land price levels. In fact, examining the relationships involved in industrial land transfers in game terms need be not only limited to the Lishui City in Zhejiang Province, but also competition in the Yangtze River Delta region, and

even China and Southeast Asia as a whole.

Overall, it can be concluded from the Centipede Game Model as well as the evidence from Jinyun case that the causes of low industrial land price are the intensity of inter-regional competition to attract foreign investment. In this context, as shown in Fig.1b, the slope of the industrial land rent-bidding curve will become flattened significantly, which leads to the urban sprawl phenomenon seen in many cities of China and the evidence from the Centipede Game Model is echoed with Hypothesis 2. In other words, the low land premium policy under the background of regional investment competition has interfered with the land leasing market, which influences the urban spatial structure, leading to the phenomenon of outside industrial land unfolding in the form of the expression “urban space structure expands like standing pancake” .

6 Discussion

The role that the industrial land premium has played in China’s urban expansion is inseparable from China’s position as the “World factory”. Though county-level government in China is politically centralized, inter-county competition is very intensive. For example, the construction of industrial parks is not only pegged to the county’s financial system but also acts as a critical factor in the performance evaluation of local officials. Therefore, there should be reasonable inter-regional planning guidance to achieve inter-regional “win-win” development in the future.

- Local financial system

The strategy by local government to adopt a low industrial land transfer price is determined to some extent by local financial considerations. A significant local government source of income is through Value-added Tax (VAT), accounting for approximately 60% of overall tax revenue (Bai, 2010). Therefore, it is in the local government's fund-raising interest to attract as much foreign investment as possible for building factories in order to secure the associated VAT returns. This has in fact become the root cause of the current so-called low-level redundant construction throughout China (Wang, 2004). In contrast, the main sources of government revenue in many developed countries are property taxes. For example, local government property taxes in the USA in 1975 accounted for 51.2% of total tax revenue (Barlowe, 1978). This is due to property tax being transparent and stable - providing a steady stream of revenue for local governments (Youngman and Malme, 2004).

Since the beginning of 2011, China has been trialing property taxes in Shanghai, the largest city by population in the People's Republic of China (Shanghai Municipal Government, 2011). To date, however, the property tax is being used mainly to curb the rapid increase of housing prices in these locations (Han *et al*, 2011). In view of what has been written above, it would seem that China would benefit more in future from a property tax levy to provide a stable source of finance for local governments. In addition, such a move could also provide some social equity concerning resource consumption and enable the city to provide infrastructure and production space as well as living space, obviating the current overreliance on foreign investment in industrial park building.

- Local government performance evaluation

Since Deng Xiaoping's *Development is the absolute principle* theme, a number of local

governments now pay most of their attention to revenue generation at the expense of the local ecological environment (Managia and Kanekob, 2009). In particular, the accelerated development of industrial parks has resulted in a weakening of pollution control in these areas, leading to serious environmental degradation. For example, Qiantang River, the largest in Zhejiang Province, plays a critical role in water supply, electricity generation, irrigation, tourism, fishery and shipping in the Qiantang River basin. As is acknowledged by Su *et al* (2011), the Qiantang River basin is one of the most rapidly advanced economic regions in China, and is now known as 'the world's workshop'. However, it is widely acknowledged that the water quality of the Qiantang River continues to deteriorate, mainly due to industrial wastewater pollution (Huang *et al*, 2010). Compared with the previous year, the changes Zhejiang province's industrial wastewater yearly discharge rates in the period of 2006-2010 are '+3.74%', '+0.50%', '-7.58%','+1.45%', and '+6.88%' respectively (Zhejiang Environmental Protection Office, 2011). Therefore, it is obvious that, with the exception of the decreased rate of '7.58%' in 2008 due to the Global Financial Crisis (GFC) affecting industrial production and causing a fall in the production of industrial wastewater emissions, the rate of industrial wastewater discharge is generally increasing. In addition to water pollution, air quality and heavy metal soil pollution are also very serious issues, creating a potential health hazard for many local residents (Chan and Yao, 2008; Li et al, 2009). A change is therefore needed from the current GDP based revenue focus of local government to one that places greater emphasis on people's livelihood and environmental protection.

- Regional planning

By using the "centipede game model" in Jinyun County, the economic theory of "fallacy of

composition" was illustrated. That is, although the individual (non-cooperative) strategy of each local government is locally rational, the intensity of competition is such that the combined effect of all the local governments involved is non-rational. One approach to overcoming this is to establish cooperative relationships between the regions to reduce the intensity of the competition. In an attempt to do this, the State Council have adopted a Development Priority Zoning (DPZ) strategy and which, bearing in mind the importance of the region, may have a significant impact on the regional land use in China (Wu *et al*, 2011).

The overall industry production in China is characterized by the "excess production capacity" of very similar types of industries. Possibilities for diversification exist, however, that may offer increased benefits in addition to relieving some of the current intense competition. For example, by matching industry development plans more to the economic conditions of the Counties. Taking Lishui city as an example, the Liandou district, Jinyun County and Qingtian County, being more economically developed, make it more rational to develop an ecological industry (such as tourism) in other mountainous counties in line with the DPZ strategy. In short, it may be better for local government to transfer land development rights from those mountainous counties to other counties with better locations. In this way, a transfer payment system among regions could be established to avoid overly intense competition, improve industrial land transfer prices and hence correcting the current land use imbalance hindering agricultural facilities and production.

China's commitment to a market economy could hardly allow such an arrangement to continue. What is needed in the longer term, is a comprehensive reform of the local financial system, government performance evaluation, and regional planning.

7 Conclusions

China is now experiencing a rapidly advancing industrialization stage, with its own rationale towards industrial land development based on changing from an extensive to intensive form of urban land use. However, attempting to attract foreign investment by a low industrial land price strategy at the County level has resulted in a disproportionally large amount of industrial land within the total urban land use structure at the expense of land needed for agriculture. The main cause of this situation appears to be the intense competition from other counties because of their adoption of the same strategy, a phenomenon reproduced by the "centipede game model" presented in this paper. As Wu (2007) points out, the vicious competition is likely to bring about chaos to China's industrial layout, reducing the core competitiveness of China's industrial products in the international market in the long run.

One possible approach to redressing this situation would be to establish inter-regional cooperative partnerships aimed at avoiding future cutthroat competition and price wars. Also, a multi-pronged approach from financial institutions and regional planners as well as local government performance evaluation measures may ultimately achieve the change from extensive to intensive urban land use needed. From a practical industrial land management perspective, the former would be a short-term strategy to ensure a reasonable minimum level of industrial land transfer prices and therefore indirectly regulate the amount of industrial land available. This should have the effect of raising and stabilizing the price of industrial land generally in China in future. Meanwhile, however, it is crucial to monitor the industrial land premium rationally to control the regional competition between regions, which can further

achieve the shift needed from the extensive to intensive land use mode in order to obtain sustainable economic growth in China in the long run.

Acknowledgements

The authors appreciate Mr. Wei Sun, in the Land Surveying and Planning Institute of Lishui City and Mr. Wei Quan at Heilongjiang Land Institute for their generous help in collecting data and background information. The authors also appreciate the kind financial support from the National Natural Science Foundation in China (70973106).

References

Adams, D., C. De Sousa and S. Tiesdell (2010). Brownfield development: a comparison of North American and British approaches. *Urban Studies* 47.1, 75-104

Alonso, W. (1964) Location and land use: toward a general theory of land rent. *Cambridge: Harvard University Press*.

Aumann, R.J. (1998) On The Centipede Game. *Games and Economic Behavior* 23, 97-105.

Bae, Y. and J.M. Sellers (2007) Globalization, the developmental state and the politics of urban growth in Korea: A Multilevel Analysis. *International Journal of Urban and Regional Research* 31.3, 543–60.

Bai, J. (2010) Reflect on Value Added Tax reform in China. *China Chief Financial Officer*, (4):94-94. (in Chinese)

Barlowe, R. (1978) *Land resource economics: the economics of real estate*. Prentice-Hall, Inc.,

Englewood Cliffs, NJ

Bhattaa, B. (2009) Modelling of urban growth boundary using geoinformatics. *International Journal of Digital Earth* 2.4, 359-381

Binmore, K. (1987) Modelling rational players (Part I). *Economics and Philosophy* 3.2,179-214.

Brown, L.R. (1995) Who will feed China? Wake up call for a small planet. *World watch Institute; W. W. Norton & Co.*

Chan, C.K. and X. Yao (2008) Air pollution in mega cities in China. *Atmospheric Environment* 42.1, 1-42.

Chen, C.Z. (2004) "The fever of development zones: it is the time to cool down", available from website: http://www.mlr.gov.cn/xwdt/dfdt/200406/t20040625_583345.htm [Retrieved on 20th June, 2011]

Chen, G.Q., R.F. Mao and L.H. Xu (2006) On the strategic choice of government administrative reform in the county level. *Journal of Public Management* 3.4, 81-6.

Chenery, H.B. and L. Taylor (1968) Development patterns: among countries and over time. *The Review of Economics and Statistics* 50.4, 391-416.

Ding, C. (2003) Land policy reform in China: assessment and prospects. *Land Use Policy* 20.2,109-20.

Feng, K., C.F. Wu, H.Y. Han and Y.Z. Wu (2010) Study on the Implementation Evaluation of Urban Construction Boundary in Land Use Planning：A Case Study of Hangzhou. *Journal of Natural Resources* 25.3, 376-385. (in Chinese)

Gu, X., H. Jiang, T.C., Wang and F.T. Qu (2009) Evaluation of intensive use of industrial land

and industrial structure adjustment：a case study of Jiangsu Province. *Resources Science* 31.4, 612-8 (in Chinese).

Han, J., Y.X., He and L.Y. Zhu (2011) The initial implementation of China's property tax reform , available from website: http://www.gov.cn/jrzg/2011-01/28/content_1794110.htm [Retrieved on 28th January, 2011].

Hong, Y.M. (2007) Serious problems exist in the extensive utilization of industrial land in urban areas. *Beijing Observation* 9, 14 (in Chinese).

Huang, F., X. Wang, L. Lou, Z. Zhou and J. Wu (2010) Spatial variation and source apportionment of water pollution in Qiantang River (China) using statistical techniques. *Water Research* 44.5, 1562–72.

Jia, H.J., X.J. Huang, S.T. Yu, G.H. Wang and Z.Q. Zheng (2010) Status of intensive use of industrial land in China and the countermeasures for improving it. *China Land Science* 24.9, 52-6 (in Chinese).

Jia K, Yan K (2005) Long-term Thinking to Improve the Reform of Fiscal System under Province. *Management World* 8, 33-37 (in Chinese)

Lao, J.J., H.S. Cai (1992) H*ong Kong urban development and management*. Hong Kong: Zhonghua Book Company (in Chinese)

Li, F., Z. Fan, P. Xiao, K. Oh, X. Ma and W. Hou (2009) Contamination, chemical speciation and vertical distribution of heavy metals in soils of an old and large industrial zone in Northeast China. *Environmental Geology* 57.8, 1815-23.

Li, W.F., X.F. Wu and X.P. Yang (2008) Study on economical and intensive use of industrial

land in Ningbo. *China Land Science* 22.5, 23-7 (in Chinese).

Liu, J.G., Thomas D, Stephen R C, *et al*. (2007) Complexity of coupled human and natural systems. *Science* 317.5844, 1513-16.

Lu, X.L., G.Q. Yang and W. Wang (2006) Mechanism analysis on the industrial land sprawl of small town: the case study on Tongcheng County and Xiantao City of Hubei. *Areal Research and Development* 25.2, 96-100 (in Chinese).

Lubell, M., R.C. Feiock and E.E.R. De La Cruz (2009) Local institutions and the politics of urban growth. *American Journal of Political Science* 53.3, 649–65.

Managia, S., Kanekob, S. (2009) Environmental performance and returns to pollution abatement in China. *Ecological Economics* 68.6, 1643–51.

Miller, D. and G. De Roo (1997) *Urban environmental planning: policies, instruments, and methods in an international perspective,* Aldershot: Ashgate Publishing

Ministry of Civil Affairs of the People's Republic of China (MCA), (2012). Statistical bulletin social service development in 2012, available from website: http://cws.mca.gov.cn/article/tjbg/201306/20130600474746.shtml

O'Sullivan, A. (2000) *Urban economics,* 4th ed., The McGraw-Hill Companies, Inc

Praetz, P.D., (1972) The distribution of share price changes. *The Journal of Business* 45.1, 49-55.

Rosenthal, R. (1981) Games of perfect information, predatory pricing, and the chain store. *Journal of Economic Theory* 25.1, 92-100.

Shanghai Municipal Government (2011) Interim Measures on the individual housing levy property tax reform at Shanghai, available from website:

http://www.csj.sh.gov.cn/pub/xxgk/zcfg/dcs/201101/t20110127_305661.html [Retrieved on 27th January, 2011]

Sigman, H. (2010) Environmental liability and redevelopment of old industrial land. *Journal of Law and Economics* 53.2, 289-306.

Sperry-Taylor, A.T. (2011) Bounded rationality in the Centipede Game. *Episteme* 8.3, 262-80.

Su, S., D. Li, Q. Zhang, R. Xiao, F. Huang and J. Wu (2011) Temporal trend and source apportionment of water pollution in different functional zones of Qiantang River, China. *Water Research* 45.4, 1781-1795.

Wang, D.J. (2004) Repetitive construction and the fiscal and taxation system. *Environmental Economy*7, 59 (in Chinese).

Weber, A., C. Friedrich (1929) *Theory of the location of industries*. University of Chicago Press.

Wen, J.B. (2005) Instructions of the eleventh five years planning proposal for the national economy and social development. *People's Daily* 2005-10-20: 001 (in Chinese).

Wong, S.W. and B.S. Tang (2005) Challenges to the sustainability of development zones: a case study of Guangzhou Development District, China. *Cities* 22.4, 303-16.

Wu, Y.Z. (2007) On regional equilibrium of industrial land price and management strategy based on game theory, *Journal of Zhejiang University (Humanities and Social Sciences)* 37.4, 124-33 (in Chinese).

Wu, Y.Z, H.J. Bao, C.F. Wu and B.G. Xu (2002) Land use under PRED. *Issues in Agricultural Economy* 2, 13-7 (in Chinese).

Wu, Y.Z,, Y. Peng, X.L. Zhang, M. Skitmore and Y. Song (2011) Development priority zoning

(DPZ)-led scenario simulation for regional land use change: The case of Suichang County, China. *Habitat International* 36.2, 268-77.

Xu, J., A.G.O. Yeh and F.L. Wu (2009) Land commodification: new land development and politics in China since the late 1990. *International Journal of Urban and Regional Research* 33.4, 890-913.

Youngman, J. and J. Malme (2004) The property tax in a new environment: lessons from international tax reform efforts, International Studies Program Public Finance Conference: The Challenges of Tax Reform in a Global Economy, available from website:http://scholar.googleusercontent.com/scholar?q=cache:kpyGohaJuroJ:scholar.google.com/&hl=zh-CN&as_sdt=0

Zhang, K.H. 2006. *China as the world factory*. Routledge: Oxon, UK.

Zhao, P.J., B. Lü and J. Woltjer (2009) Conflicts in urban fringe in the transformation era: an examination of performance of the metropolitan growth management in Beijing. *Habitat International* 33.4, 347-56.

Zhejiang Environmental Protection Office, (2011) *Zhejiang environment statistical review (2006-2010)*. available from website: http://www.zjepb.gov.cn/root14/xxgk/index.htm?classInfoId=1584 [Retrieved on 24th August, 2012]

Zhu, J.M. (1994) Changing land policy and its impact on local growth: the experience of the Shenzhen Special Economic Zone, China, in the 1980s. *Urban Studies* 31.10, 1611-23.

Zhu, J.M. (2000) The impact of industrial land use policy on industrial change. *Land Use Policy* 17.1, 21-8.

Ziegler, E.H. (2009) The case for megapolitan growth management in the twenty-first century: regional urban planning and sustainable development in the USA. *International Journal of Law in the Built Environment* 1.2, 105-29.